Nearshore Wave-Topography Interactions

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LONG-TERM GOAL

My long term goal is to develop a predictive understanding of the fluid dynamics of a random wave field shoaling over the complicated bathymetry of a natural beach, and the response of the beach to those overlying wave and current motions. Success requires improvements in understanding and modeling as well the development of innovative methods for collecting measurements needed to seed those models.

OBJECTIVES

Over the last decade, our scientific focus was on the development and implementation of an extensive, robust sampling capability for nearshore processes (the Argus Program) and documentation of the plethora of new phenomenology that were observed. Our current work sees a re-focussing on understanding the physics of electro-optical imaging. We wish to develop a physics-based model for the Modulation Transfer Function (MTF) relating optical radiance to underlying geophysical variables. Thus, observations will shift from a basis in contrast (for waves) and morphology (patterns of sand) to actual time series of sea surface elevation and bathymetry.

APPROACH

Our approach is a mix of mining and extension of existing literature and ground-truth testing. Optical oceanography is a small but growing field that seeks to understand the physics of light in the ocean from a mix of fundamental theory and empiricism. The primary interest of optical oceanographers is usually to infer properties of the ocean interior, with transmission and reflection from the surface a complication [*Kirk*, 1994; *Mobley*, 1994; *Walker*, 1994]. In contrast, upwelling radiance from the interior is a complication to our research as we hope to isolate surface-related signals (maximizing reflection) through choice of optical wavelength and polarity. We are currently developing forward models of observed radiance from a wavey surface. Components of this model include models for skydome source radiance, surface reflection and upwelling transmission. Most effort has focussed on low-amplitude waves, away from breaking. However, intitial work on radiance signals from breaking waves is also being carried out.

WORK COMPLETED

The primary ground-truth database for this work comes from the SandyDuck field experiment, held in 1997. Figure 1 shows an example cross-spectrum between in-situ pressure data supplied by Elgar et al and optical radiance at the mean sea surface location corresponding to the pressure sensor. The strong coherence between the optical and pressure signal is reassuring although not surprising. Through our modeling, we must explain both the relative phase and the magnitudes between these signals.

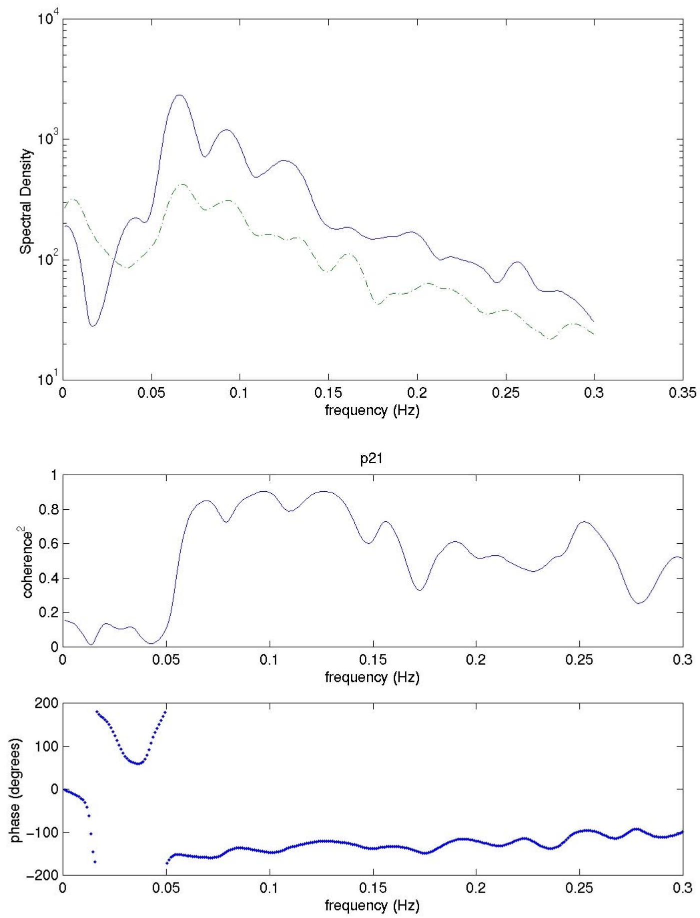

Figure 1 Cross-spectrum between pressure (solid line) and optical radiance. Note that both spectra show the same dominant peak structure and are very coherent with a relative phase of -160 degrees.

While our main emphasis has been on the SuperDuck data set, we also participated in several further field efforts, aimed at expanding our database for EO ground-truthing. In the Fall of 1999, we participated in a joint rip current experiment at Palm Beach, Australia, a site known for its dynamic rip system. One component of this work was the testing of a light-tracking scheme for the measurement of rip currents. Figure 2 shows a surprising example result in which the float was carried steadily offshore at a rate of 30 cm/sec. While we had expected offshore movement in the rip, then slow recirculation, the float continued well beyond the rip cell, progressing offshore for 30 minutes (the limit of our imaging) despite a lack of wind or other apparent forcing.

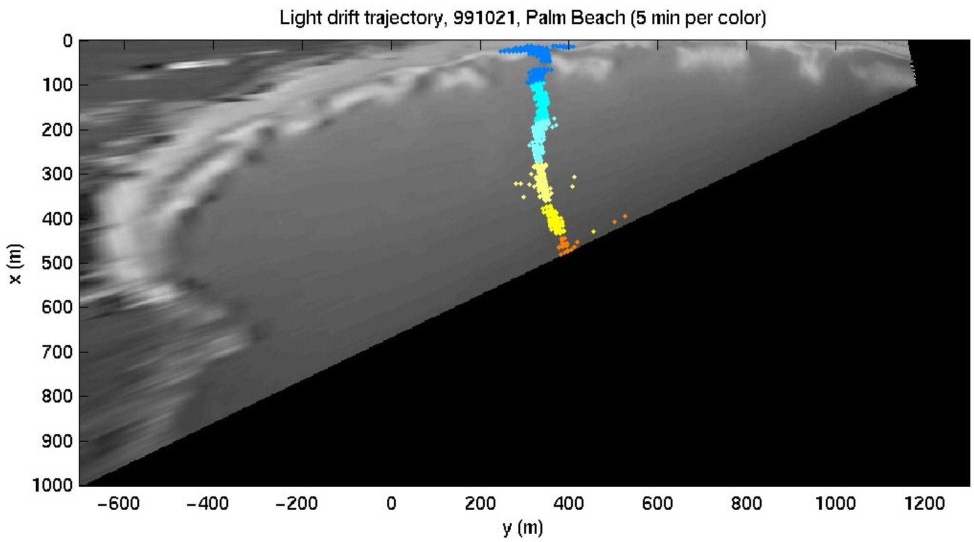

Figure 2. Offshore drift of a man-overboard light seeded in a rip current at Palm Beach, Australia. Despite a lack of wind or other apparent forcing, the light moved offshore at a steady 30 cm/sec for at least 500 m, well beyond the extent of the rip cell. Different colors indicated consecutive five-minute periods. The track is overlain on a rectified time exposure image from the previous day to provide spatial orientation.

Short field efforts were also made as part of the Showex experiment at Duck, NC and the Coast3D experiment at Teignmouth, England.

RESULTS

Our single most important accomplishment over the last decade has been the development and implementation of the low-cost method for sampling nearshore dynamics in a wide range of environments over long periods of time, the Argus Program. Argus data represent the single most-extensive archive of coastal variability in the world, are the subject of research of scientists world-wide and have revealed a host of new phenomenology. Improved understanding of the physics of optical signals, hence the MTF relating optical to traditional nearshore geophysical signals, is in progress. In combination with existing simple Argus sampling strategies, these will provide invaluable long term data sets in the future.

IMPACT/APPLICATION

This research has direct application in both civilian and defense communities. Data and understanding acquired in the Argus program will be very relevant to issues of battlespace environment characterization, particularly for one week of longer look-aheads. Because the Argus program includes 10 sites spanning the full range of beach types, the understanding developed should be relevant to more than just Duck-like coasts. Techniques developed to quantify EO imagery for the extraction of geophysical variables can be readily applied to moving platform remote sensing, with the addition of only frame-dependent image navigation.

TRANSITIONS

Argus technology has been embraced by NRL-SSC in a program run by Dr. Todd Holland. We continue to have strong collaboration with his group, including cooperative work associated with the VISSER station at Camp Pendleton. We continue collaboration with the U.S. Army Corps of Engineers both through Bill Curtis at Vicksburg and through the FRF on a variety of Argus issues. Skills and ideas in handling EO data developed due to Argus interest have lead to the PI spending substantial lengths of time either at Navoceano, or at OSU, working directly on problems of implementation of nearshore remote sensing to Naval needs. The PI is also involved in the LRS program and continuing interactions with government and contractor scientists.

RELATED PROJECTS

1 - Joint work with Dr. Todd Holland, NRL-SSC

2 - Collaboration and data sharing of pixel time stack data with Dr. Jim Kaihatu or NRL-SSC

3 – Collaboration with Craig Cobb of the WSC at Navoceano on nearshore remote sensing

4 – LRS program collaboration

5 – NICOP joint program with several European groups

6 – NICOP joint program with Dr. Graham Symonds of Australia

7 – Joint work with Bill Curtis of US Army Corps

8 – Numerous collaborations with the Field Research Facility

9 – participation in SHOWEX

REFERENCES

Kirk, J.T.O., *Light and photosynthesis in aquatic ecosystems*, 509 pp., Cambridge University Press, New York, 1994.

Mobley, C.D., *Light and water, radiative transfer in natural waters*, 592 pp., Academic Press, Inc, San Diego, 1994.

Walker, R.E., *Marine light field statistics*, 675 pp., John Wiley and Sons, Inc., New York, 1994.

PUBLICATIONS

Foster, D.L., R.A. Beach, and R.A. Holman, Field Observations of the wave bottom boundary layer, *Journal of Geophysical Research*, *105* (C8), 19631-19647, 2000.

Holman, R.A., Waves on Beaches, in *Encyclopedia of Ocean Sciences*, edited by J. Steele, S. Thorpe, and K. Turekian, Academic Press, London, in press.

Konicki, K., and R.A. Holman, The statistics and kinematics of transverse sand bars on an open coast, *Marine Geology*, *169*, 69-101, 2000.

Plant, N.G., M.H. Freilich, and R.A. Holman, The role of morphological feedback in surf zone sand bar response, *Journal of Geophysical Research*, in press-a.

Plant, N.G., R.A. Holman, and M.H. Freilich, A simple model for interannual sand bar behavior, *Journal of Geophysical Research*, in press-b.

Puleo, J.A., R.A. Beach, R.A. Holman, and J.S. Allen, Swash Zone sediment suspension and transport and the importance of bore-generated turbulence, *Journal of Geophysical Research*, *105* (C7), 17021-17044, 2000.

Stockdon, H.F., and R.A. Holman, Estimation of wave phase speed and nearshore bathymetry from video imagery, *Journal of Geophysical Research*, *105* (C9), 22,015-22,033, 2000.